J. Agric. Sci. Mansoura Univ., 25 (8) 5425 - 5440, 2000.

EFFECT OF *Meloidogyne incognita* ON GROWTH AND YIELD OF SUSCEPTIBLE AND RESISTANT TOMATO CULTIVARS AND EFFECT OF VARIOUS APPLIED ORGANIC MANURES ON NEMATODE CONTROL

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ABSTRACT

Two pot experiments were simultaneously conducted during the early summer seasons of 1997 and 1998.

The first experiment studied the effect of four initial population (P_i) densities of *Meloidogyne incognita* (0, 4×10^3, 10×10^3 and 20×10^3 nematode eggs/pot) on growth and yield of susceptible (Castlerock) and resistant (F_1 hybrid Heinz 2710) tomato cultivars. The susceptible cv. was greatly suppressed by *M. incognita* in most growth and yield parameters, viz., stem length, number of leaves, leaf fresh and dry weight, root fresh weight, chlorophyll and N, P, K content of leaves, fruit yield per plant and average fruit weight. Meanwhile, the resistant cv. was slightly affected. On the other hand, titratable acidity and vitamin C and T.S.S. content of fruits were higher in the susceptible cv. Final nematode population (P_f), root gall index and reproduction factor (R_f) were significantly higher in the susceptible cv. as compared with the resistant one.

A negative relationship was found between P_i and most vegetative growth parameters, where gradual decreases were observed with the increase in P_i. However, a positive relationship was found between root fresh weight and P_i. Fruit yield per plant decreased with the increase in P_i. Average fruit weight significantly decreased at P_i 20×10^3 as compared with the control. Fruit acidity and vitamin C content decreased at most P_i levels. P_f increased with the increase in Pi level. Root gall index ranged from 0.0 in the control to 5.0 in the various inoculum levels used. R_f increased with the increase in P_i up to 10×10^3.

The interaction between tomato cultivar and P_i had a significant effect on leaf fresh weight, leaf chlorophyll content and fruit yield per plant, where the 0.0 level with the resistant cv. had the highest records. However, this treatment had the lowest root fresh weight. The lowest P_f was obtained when the 4×10^3 level was used with the resistant cv. Root gall index was only slightly affected by the P_i level in the resistant cv., but was greatly affected in the susceptible one. The lowest R_f was obtained when the 20×10^3 level was used with the resistant cv.

The second experiment studied the efficacy of four organic manures (rabbit, pigeon, cow and poultry) in controlling *M. incognita* in tomato. All organic manures improved most plant growth and yield parameters, i.e., stem length, number of leaves, leaf fresh and dry weight, root fresh weight, leaf chlorophyll and N, P, K content, fruit yield per plant, average fruit weight, and fruit acidity and vitamin C and T.S.S content. Applying pigeon and poultry manure increased these parameters more than rabbit or cow manures. All organic manures suppressed P_f, root gall index and R_f. However, pigeon and poultry manures caused more suppression in root gall index and R_f and pronounced increase in nematode reduction % as compared with cow and rabbit manures.

INTRODUCTION

Meloidogyne incognita (Kofoid and White) Chitwood is a destructive pest of vegetable crops, including tomato, okra and chillies (Johnson and Fassulitis, 1984). Ogunfowora (1977) found that the marketable yield of 7 tomato cvs. was considerably reduced at all tested inoculum levels of *M. incognita*. A progressive decline in the growth and yield was observed with increasing nematode population (Chindo and Khan, 1988).

Vito and Lamberti (1976) studied the reaction of 1 susceptible and 4 resistant tomato cvs. to inoculation with 12 Italian populations of *Meloidogyne* spp. These populations showed different degrees of pathogenicity to susceptible cvs. and some growth reduction in resistant cvs.

Vito *et. al*. (1991) studied the relationship between initial population density of *M. incognita* race 1 and yield of susceptible and resistant tomato cvs. They found that fruit size and marketable yield of the susceptible cv. were negatively affected with nematode infestation. Inoculation of tomato with different inoculum levels of *M. incognita* at seedling stage reduced top and root growth more severely than inoculation later (Singh, 1975). Anwar and Van Gundy (1993) studied the relationship between *M. incognita* population densities and root and shoot growth parameters of susceptible and resistant tomato cvs. in a controlled environment. Root growth reduction of the susceptible cv. caused by nematode resulted in a reduction in shoot growth, whereas the slight root damage to the root system of the resistant cv. did not cause reduction in shoot growth.

Bird (1974), Ali *et al*. (1981) and Omar *et al*. (1985) stated that root-knot nematode infection significantly reduced total photosynsthetic pigments (Chlorophyll a, b and a + b).

Ogunfowora (1977) and Dwivedi and Pandey (1993) reported that root-galling in tomato increased with increasing initial population levels. Also, Chindo and Khan (1988) found that the degree of damage associated with nematodes was correlated with root-gall index and nematode population.

Soil organic amendments have been used as an alternative method in the control of plant parasitic nematodes. Waste materials of animals and birds have been used effectively to control many species of economically important phytonematodes (Alam *et al*., 1979; Muller and Gooch, 1983; Montasser, 1991; Ismail, 1997; Amin and EL-Shafeey, 1998). The beneficial effect of chicken manure amendment as a nematicide for controlling phytonematode has been also documented (Mian and Rodriguez Kabana, 1982; Amin and EL-Shafeey, 1998). Application of poultry, cow and sheep manures as soil organic amendments, significantly reduced populations of *M. javanica* and *M. incognita* and significantlly increased yield of tomato and eggplant (Babatola, 1989; Stephan, 1995; Montasser, 1991; Ismail, 1997; Amin and EL-Shafeey, 1998).

Chavarria Carvajal and Rodriguez Kabana (1999) indicated that most organic amendements were effective in reducing root-galling and root-knot nematodes and increasing populations of non-parasitic nematodes. They suggested that complex modes of action operating in amended soils are responsible for suppression of *M. incognita*.

The present study was conducted to determine the effect of different inoculum levels of *M. incognita* on growth and yield of susceptible and resistant tomato cvs. and to show the effectiveness of four common available organic manures in controlling *M. incognita* in tomato.

MATERIALS AND METHODS

Two pot experiments were simultaneously conducted in the Faculty of Agriculture, Kafr EL-Sheikh, Tanta University during the early summer seasons of 1997 and 1998.

Experiment A aimed at studying the effect of initial population density levels (P_i) of *M. incognita* on growth and yield of susceptible and resistant tomato cultivars. The experiment included two tomato cultivars (The susceptible Castlerock and the resistant F_1 hybrid Heinz 2710) and four P_i levels of *M. incognita*, viz., 0, 4×10^3, 10×10^3 and 20×10^3 nematode eggs/pot). Seeds of Castlerock were obtained from local sources, while seeds of Heinz 2710 were kindly provided by Heinz Co., U. S. A. Tomato seeds were sown under plastic cover on 15 January in the two seasons. Six weeks later, seedlings were transplanted into 20 cm pots (one seedling per pot) in the open. One week later, pots were inoculated with the four P_i levels, where each level was suspended in 10 ml of tap water and pipetted into the soil medium near the roots. Zero level served as control. Treatments were replicated four times and pots of various treatments were completely randomized. Each experimental unit consisted of 15 pots. Pots were irrigated and fertilized whenever it deemed necessary.

Fifty days after transplanting, plants (as samples of five per experimental unit) were carefully uprooted, washed and air dried. The following parameters were determined: stem length, number of leaves, leaf fresh and dry weight and leaf chlorophyll (a, b and a + b) and N, P, and K content. Chlorophyll content was estimated by a spectrocolorimeter, using N, N-dimethylformamide as described by Moran and Porath (1980) and Moran (1982). Leaf samples dried at 70°C were finely ground, wet digested and total N, P, and K contents were determined in the digestion product. Nitrogen was determined using the Micro-kjeldahl method (Piper, 1947). Phosphorus was estimated colorimetrically, using a spectrophotometer at 725 μm. (King, 1951). Potassium was determined using a flame photometer (Jackson, 1967).

At harvest, total plant fruit yield, average fruit weight and fruit content of acidity, vitamin C and total soluble solids (T.S.S.) were determined. Acidity (citric acid%) and vitamin C (ascorbic acid as mg/100 ml fruit juice) were determined as recommended by Cox and Pearson (1962). T.S.S. was determined by a hand refractomater.

At the end of the harvesting period, the remaining plants were uprooted and the roots were carefully washed and air dried. Root fresh weight was determined. The total number of galls per root system was counted, and the root gall index was rated on the 0-5 scale of Taylor and Sasser (1978). The final nematode population (P_f) as J_2/250 cm^3 soil was estimated after extraction by modified Cobb's sieving and decanting method (Southey, 1986). Reproduction factor (R_f) as (p_f/P_i) was calculated for each treatment. Nematode reduction % was calculated for each treatment according to the following formula:

$$\text{Nematode reduction \%} = \frac{P_f \text{ control} - P_f \text{ treatment}}{P_f \text{ control}} \times 100$$

Data were statistically analyzed. A factorial in complete randomized design was applied. Duncan's multiple range test was used for the comparisons among treatment means (Duncan, 1965).

Experiment B aimed at studying the effect of some organic manures on growth and yield of tomato plants infested with the root-knot nematode *M. incognita.* Four organic manures, viz., rabbit, pigeon, cow and poultry were air dried and passed through 2 mm sieve before use. The amendments were mixed thoroughly with autoclaved loamy soil at the rate of 4% w/w and transferred into 20 cm pots. Unamended soil served as control. The pots were watered daily, and kept for 2 weeks to permit partial decomposition of the amendments.

Seedlings of cv. Castlerock. (6 weeks old) were transplanted into pots at the same date as mentioned above in experiment A. One week later, each pot was inoculated with approximately 4×10^3 *M. incognita* eggs/pot. Each experimental unit consisted of 15 pots. Four replications were used for each treatment. Pots were arranged in a complete randomized design.

Plant growth parameters, fruit yield and nematode reproduction were measured as described above for experiment A, and at the same dates. Data were statistically analyzed. A complete randomized design was applied. Duncan's multiple range test was used for the comparisons among treatment means (Duncan, 1965).

RESULTS

Experiment (A):

1. Response of tomato cultivars.

Results in Table 1 indicate that the resistant tomato cv. Heinz 2710 showed significantly higher values in most growth parameters, viz., stem length, number of leaves per plant, leaf fresh and dry weight and root fresh weight in the two seasons as compared with the susceptible cv. Castlerock. Also, chlorophyll (a, b and a + b) contents were significantly higher in the resistant cv. in both seasons. Differences in the N, P and K contents were mostly not significant between the two cvs. in both seasons.

Table (1): Response of tomato cvs. Heinz 2710 (resistant) and Castlerock (susceptible) to various inoculum densities of *M. incognita*, with respect to vegetative growth parameters and leaf chlorophyll and N, P and K content in the 1997 and 1998 seasons.

Cultivar	Stem length (cm)	No. of leaves/ plant	Leaf fresh weight (g)	Leaf dry weight (g)	Root fresh weight (g)	Chl. a	Chl. b	Chl. (a+b)	Total N,P and K (% dry weight)		
						mg/dm^2			N	P	K
	1997										
Heinz 2710	42.84	20.28	57.21	9.54	47.85	5.14	4.05	9.19	4.52	0.76	3.32
Castlerock	41.1	15.91	45.55	7.75	44.45	4.79	3.69	8.48	4.54	0.69	3.15
F. test	*	**	**	**	*	*	*	*	N.S	N.S	N.S
	1998										
Heinz 2710	35.11	22.04	58.51	11.75	43.04	5.19	3.93	9.12	4.87	0.74	3.31
Castlerock	33.76	17.58	46.42	9.92	42.43	4.79	3.77	8.47	4.36	0.73	3.07
F. test	N.S	*	*	*	N.S	*	*	*	*	N.S	N.S

***, ** and N.S. indicate $P<0.05$, $P<0.01$ and not significant, respectively, according to F. test.**

Data in Table 2 indicate that fruit yield per plant and average fruit weight were significantly higher in cv. Heinz 2710 in both seasons. However, fruit acidity and vitamin C and T.S.S. contents were significantly higher in the susceptible cv. Castlerock in most cases in both seasons. Final nematode population (P_f) was significantly higher in Castlerock as compared with Heinz 2710. Similarly, large differences were observed between the two cvs. in root gall index and R_f in both seasons.

Table (2): Response of tomato cvs. Heinz 2710 (resistant) and Castlerock (susceptible) to various inoculum densities of *M. incognita*, with respect to fruit yield and quality of plants and nematode reproduction in the 1997 and 1998 seasons.

Cultivar	Fruit yield/ plant (g)	Average fruit weight (g)	Acidity (%)	Vitamin C mg/100 ml fruit juice	Total soluble solids (%)	Final nematode population (P_f) J_2/ 250 cm^3 soil	Root gall index (0-5)	Reproduction factor (R_f)=P_f / P_i
	1997							
Heinz 2710	317.03	49.01	0.44	19.91	4.66	98.94	1.0	0.0116
Castlerock	207.38	40.29	0.56	20.91	5.69	1081.38	5.0	0.127
F. test	**	**	*	*	*	**		
	1998							
Heinz 2710	356.26	47.95	0.57	19.60	5.20	104.07	1.0	0.0122
Castlerock	235.82	42.74	0.59	21.92	5.70	1167.69	5.0	0.137
F. test	*	*	N.S	*	N.S	**		

***, ** and N.S. indicate $P<0.05$, $P<0.01$ and not significant, respectively, according to F. test.**
R_f = reproduction factor P_f = final population P_i = initial population.

2. Effect of initial *M. incognita* population density level *.*

Data in Table 3 indicate that the control treatment (zero level) had significantly the highest values in most growth parameters, viz., stem length, number of leaves per plant, leaf fresh and dry weights and chlorophyll (a, b and a + b) and N, P and K contents. A negative relationship was found between P_i and these parameters, where gradual reductions were observed with each increase in P_i. However, the values of N, P and K at the levels 4 ×

10^3 and 10×10^3 were not significantly different. Meanwhile, a significant positive relationship was found between root fresh weight and P_i.

Data in Table 4 show that fruit yield per plant decreased proportionally with the increase in P_i, leading to yield loss of 7.2, 20.2 and 29.5% in the first season, and 10.0, 25.7 and 38.3% in the second one when inoculum levels were 4×10^3, 10×10^3 and 20×10^3, respectively. Average fruit weight was significantly lower at P_i 20×10^3 inoculum level as compared with the control in both seasons. Fruit acidity and vitamin C content significantly decreased at all P_i levels as compared with the control, but the differences of vitamin C values were not significant in the second season. T.S. S. was not affected by P_i levels in both seasons.

Table (3): Effect of initial population density level (P_i) of *M. incognita*, infesting tomato plants, on vegetative growth parameters and chlorophyll, N, P, and K contents of leaves in the 1997 and 1998 seasons.

Initial population density level (Eggs/pot)	Stem length (cm)	No. of leaves/ plant	Leaf fresh weight (g)	Leaf dry weight (g)	Root fresh weight (g)	Chl. A	Chl. b	Chl. (a+b)	Total N,P and K (% dry weight)		
						mg/dm²			N	P	K
	1997										
0 (control)	45.75a	20.66a	54.98a	9.24a	40.71b	5.84 a	4.39a	10.23a	5.27a	0.77a	3.64a
4×10^3	44.49a	19.26b	52.46b	8.88ab	42.08b	5.08 b	4.14b	9.22b	4.53b	0.72ab	3.05bc
10×10^3	40.46b	16.78c	50.23c	8.40bc	50.13a	4.73 c	3.65c	8.38c	4.22b	0.70b	3.44ab
20×10^3	37.20c	15.68c	47.86d	8.05c	51.68a	4.24 d	3.31d	7.55d	4.10b	0.71b	2.81c
F. test	*	**	**	*	*	*	*	*	**	*	*
	1998										
0 (control)	38.13a	21.96a	56.58a	11.75	38.69d	5.88a	4.38a	10.26a	5.09a	0.78a	3.67a
4×10^3	35.81a	20.55b	52.94b	10.77	41.75c	5.07b	4.12b	9.19b	4.59b	0.75ab	3.08b
10×10^3	31.35b	18.93c	49.39d	10.26	44.30b	4.14b	3.27d	7.41d	4.51b	0.69c	3.29b
20×10^3	32.45b	17.79c	50.96c	10.57	46.20a	4.69c	3.63c	8.32c	4.28b	0.72bc	2.72c
F. test	**	*	*	N.S	**	*	*	*	*	*	*

***, ** and N.S. indicate $P<0.05$, $P<0.01$ and not significant, respectively, according to F. test. Means followed by a letter in common are not significantly different at the 5% level according to Duncan's test.**

Data in Table 4 reveales a significant increase in (P_f) with each increase in P_i in both seasons. Root gall index ranged from 0.0 (in control) to 5.0 (in the remaining inoculum levels). R_f increased to 0.092 and 0.097 with the increase in P_i up to 10×10^3 in the first and second seasons, respectively.

3. Effect of the interaction between tomato cultivar and nematode initial population density level.

Data in Table 5 indicate that the highest values of stem length were obtained with the 0.0 (control) and 4×10^3 inoculum levels in both cvs., while the shortest stems were obtained with 20×10^3 level in the susceptible cv. However, stem length was not affected by the interaction in the second season. Number of leaves per plant and leaf dry weight were not significantly affected by the interaction in both seasons. The highest leaf fresh weight was obtained with the 0.0 (control) level in the resistant cv. Heinz 2710 in both seasons, while the least values were obtained with the 10×10^3 and 20×10^3

levels in the susceptible cv. Castlerock. Data also indicate that root fresh weight was significantly affected by the interaction, where the highest weights were obtained with the 20 $\times 10^3$ and 10 $\times 10^3$ inoculum levels in the susceptible cv. in both seasons, while the least weight was obtained with the 0.0 (control) level in the same cv. Concerning chlorophyll (a, b and a + b) data indicate that the highest leaf contents resulted from using the 0.0 (control) level in both cvs. in both seasons. Meanwhile, the least contents were obtained with the 20 $\times$ 10^3 level in the susceptible cv. Castlerock in the first season and with the 10 $\times$ 10^3 level in the same cv. in the second season. Data also show that leaf N, P and K contents were not significantly different between cvs. or inoculum density levels in both seasons.

Table (4): Effect of initial population density level (P_i) of *M. incognita,* infesting tomato plants on fruit yield and quality and nematode reproduction in the 1997 and 1998 seasons.

Initial population density level (Eggs/pot)	Fruit yield/plant (g)	Average fruit weight (g)	Acidity (%)	Vitamin C (mg/ 100 ml fruit juice)	Total soluble solids (%)	Final nematode population (P_f) J_2/ 250 cm^3 soil	Root gall index (0-5)	Reproduction factor (R_f) (P_f/P_i)
				1997				
0 (control)	305.65 a	46.94 a	0.54 a	20.99 a	5.57	0.00 d	0.0	0.00
4 $\times$ 10^3	283.63 b	46.09 a	0.49 b	20.10 b	5.01	219.38 c	5.0	0.055
10 $\times$ 10^3	243.94 c	43.33 b	0.49 b	20.30 b	5.07	924.75 b	5.0	0.092
20 $\times$ 10^3	215.61 d	42.25 b	0.48 b	20.26 b	5.04	1216.50 a	5.0	0.061
F. test	**	**	*	*	N.S	**		
				1998				
0 (control)	363.25 a	47.08 a	0.65 a	21.38	5.61	0.00 d	0.0	0.00
4 $\times$ 10^3	326.81 b	46.36 a	0.55 b	20.48	5.61	255.63 c	5.0	0.064
10 $\times$ 10^3	269.86 c	54.20 a	0.54 b	20.59	5.29	971.13 b	5.0	0.097
20 $\times$ 10^3	224.24 d	42.75 b	0.57 b	20.58	5.29	1316.75 a	5.0	0.066
F. test	*	*	*	N.S	N.S	**		

***, ** and N.S. indicate $P<0.05$, $P<0.01$ and not significant, respectively, according to F. test. Means followed by a letter in common are not significantly different at the 5% level according to Duncan's test.**
R_f = reproduction factor; P_f = final population; P_i = initial population.

Data presented in Table 6 show that the highest fruit yield resulted from applying the 0.0 level (control), followed by the 4 $\times$ 10^3 level in the resistant cv. in both seasons, while the lowest fruit yield resulted from using the 20 $\times$ 10^3 level with the susceptible cv. Data also indicate that the highest average fruit weights were obtained with the 0.0, 4 $\times$ 10^3 and 20 $\times$ 10^3 levels in the resistant cv. in both seasons. Meanwhile, the lowest values resulted from applying the 20$\times$ 10^3 level to the susceptible cv. in both seasons. However, differences were not significant in the first season. Fruit acidity and vitamin C and T.S.S. contents showed no significant differences in both seasons.

Table (5): Effect of interaction between tomato cultivars and initial population density levels (P_i) of *M. incognita* on some vegetative growth parameters of tomato plants and leaf chlorophyll, N, P, and K contents in the 1997 and 1998 seasons.

Interaction Cultivars × P_i	Stem length (cm)	No. of leaves /plant	Leaf fresh weight (g)	Leaf dry weight (g)	Root fresh weight (g)	Chl. a (mg/dm^2)	Chl. b (mg/dm^2)	Chl. (a+b) (mg/dm^2)	Total N, P and K (% dry weight) N	P	K
					1997						
Heinz 2710											
0 (control)	45.47a	22.55	59.93a	10.13	45.45b	5.90a	4.35ab	10.25a	5.06	0.79	3.64
4 × 10^3	43.73ab	21.63	58.38b	9.89	45.60b	5.15b	4.21bc	9.36b	4.70	0.76	3.08
10 × 10^3	41.70bc	18.80	56.00c	9.20	49.33a	4.90b	3.91de	8.81c	4.24	0.73	3.41
20 × 10^3	40.48c	18.15	54.55c	8.93	51.02a	4.63c	3.74e	8.37d	4.08	0.76	3.14
Castlerock											
0 (control)	46.03a	18.78	50.03d	8.36	35.97c	5.78a	4.43a	10.21a	5.48	0.76	3.64
4 × 10^3	45.25a	16.90	46.55e	7.87	38.55c	5.00b	4.07cd	9.07bc	4.35	0.68	3.01
10 × 10^3	39.23c	14.75	44.45f	7.60	50.93a	4.55c	3.40f	7.95d	4.20	0.66	3.48
20 × 10^3	33.93d	13.20	41.18g	7.17	52.35a	3.85d	2.88g	6.73e	4.13	0.67	2.47
F. test	*	N.S	*	N.S	*	*	*	*	N.S	N.S	N.S
					1998						
Heinz 2710											
0 (control)	38.58	23.90	61.55a	10.87	40.97d	5.91a	4.30ab	10.21a	5.31	0.77	3.70
4 × 10^3	34.98	22.98	58.60b	12.92	42.47cd	5.25b	4.04c	9.29b	4.84	0.75	3.17
10 × 10^3	34.45	21.08	56.65c	11.51	43.83bc	4.58d	3.73d	8.31e	4.84	0.71	3.29
20 × 10^3	32.45	20.20	57.25c	11.71	44.90b	5.01bc	3.66d	8.67d	4.51	0.73	3.08
Castlerock											
0 (control)	37.68	20.03	51.60d	10.67	36.40e	5.84a	4.46a	10.30a	4.86	0.79	3.64
4 × 10^3	36.65	18.13	47.27e	10.58	41.03d	4.89c	4.20bc	9.09c	4.35	0.76	3.00
10 × 10^3	28.25	16.78	42.13g	9.01	44.78b	3.71e	2.81e	6.52g	4.18	0.68	3.29
20 × 10^3	32.45	15.38	44.68f	9.44	47.50a	4.38d	3.59d	7.97f	4.05	0.71	2.36
F. test	N.S	N.S	*	N.S	*	*	*	*	N.S	N.S	N.S

***, ** and N.S. indicate P<0.05, P<0.01 and not significant, respectively, according to F. test. Means followed by a letter in common are not significantly different at the 5% level according to Duncan's test.**

Data in Table 6 also show that P_f increased with the increase in P_i level within each cv. The lowest P_f was obtained with the 4 × 10^3 level in the resistant cv. in both seasons. Root gall index was only slightly affected by the P_i levels in the resistant cv., but was much affected by such levels in the susceptible one. The highest R_f resulted from applying the 10 × 10^3 level, followed by the 20 × 10^3 level to the susceptible cv. in both seasons. Meanwhile, the lowest R_f resulted from using the 20 × 10^3 level with the resistant cv. in both seasons.

Experiment (B):

Results in Table 7 indicate that all organic manure treatments improved plant growth as compared with unamended soil. The increase in stem length, number of leaves per plant, leaf fresh and dry weight and root fresh weight of Castlerock tomato plants varied according to the sort of organic manure used. Amending soil with pigeon or poultry manure significantly increased these growth parameters more than using rabbit or cow manure in both seasons. Also, pigeon and poultry manures significantly increased chlorophyll (a, b and a + b) and total N, P and K contents as compared with unamended soils in the two seasons.

Table (6): Effect of interaction between tomato cultivar and initial population density levels (P_i)of *M. incognita* on fruit yield and quality of tomato plants and nematode reproduction in the 1997and 1998 seasons.

Interaction Cultivars × P_i	Fruit yield/plant (g)	Average fruit weight (g)	Acidity, %	Vitamin C (mg / 100 ml. fruit juice)	Total soluble solids (%)	Final nematode population (P_f) J_2/ 250 cm^3 soil	Root gall index (0-5)	Reproduction factor (R_f) (P_f/P_i)
				1997				
Heinz 2710								
0 (control)	343.65 a	50.43	0.51	20.40	5.10	0.00 g	0.0	-
4 × 10^3	324.88 b	49.85	0.43	19.68	4.25	79.25 f	1.0	0.019
10 × 10^3	305.70 c	48.35	0.42	19.80	4.32	123.25 e	1.0	0.012
20 × 10^3	293.90 c	47.40	0.42	19.77	4.27	193.25 d	1.0	0.009
Castlerock								
0 (control)	267.65 d	43.45	0.58	21.58	5.70	0.00 g	0.0	-
4 × 10^3	242.38 e	42.33	0.55	20.53	5.40	359.50 c	5.0	0.089
10 × 10^3	182.18 f	38.30	0.56	20.79	5.52	1726.25 b	5.0	0.172
20 × 10^3	137.33 g	37.10	0.54	20.75	5.47	2239.75 a	5.0	0.111
F. test	**	N.S	N.S	N.S	N.S	**		
				1998				
Heinz 2710								
0 (control)	411.50 a	48.50a	0.64	20.12	5.51	0.00 g	0.0	-
4 × 10^3	373.03 b	48.18ab	0.54	19.35	5.06	89.75 f	1.0	0.0224
10 × 10^3	336.08 c	48.65a	0.53	19.46	5.10	131.25 e	1.0	0.0131
20 × 10^3	304.45 d	46.47abc	0.56	19.46	5.12	195.25 d	1.0	0.009
Castlerock								
0 (control)	315.00 d	45.65 bc	0.66	22.65	5.70	0.00 g	0.0	-
4 × 10^3	280.60 e	44.55 c	0.56	21.62	6.16	421.50 c	5.0	0.105
10 × 10^3	203.65 f	41.75 d	0.55	21.72	5.48	1811.00 b	5.0	0.181
20 × 10^3	144.03 g	39.03 e	0.58	21.70	5.47	2438.25 a	5.0	0.122
F. test	*	*	N.S	N.S	N.S	**		

***, ** and N.S. indicate $P<0.05$, $P<0.01$ and not significant, respectively, according to F. test.**
Means followed by a letter in common are not significantly different at the 5% level according to Duncan's test.
R_f = reproduction factor; P_f = final population; P_i = initial population.

Table (7):Effect of soil organic manure on vegetative growth parameters and leaf chlorophyll, N, P, and K contents of Castlerock tomato plants infested with *Meloidogyne incognita* in the 1997 and 1998 seasons.

Organic manure	Stem length (cm)	No. of leaves/plant	Leaf fresh weight (g)	Leaf dry weight (g)	Root fresh weight (g)	Chl. a (mg/dm²)	Chl. b (mg/dm²)	Chl. (a+b) (mg/dm²)	Total N, P and K (% dry weight) N	P	K
						1997					
Control	50.45c	17.60c	41.08c	7.15b	38.15d	4.75c	4.13c	8.88d	3.98d	0.69d	2.83c
Rabbit	55.05bc	19.55bc	43.18c	7.30b	43.53bc	5.46b	4.31b	9.77b	4.58bc	0.73c	3.30ab
Pigeon	64.40a	22.20a	53.38a	8.88a	47.45a	5.88a	4.49a	10.37a	5.08a	0.77a	3.39a
Cow	53.68bc	18.25c	42.48c	7.23b	41.18c	5.32b	4.26bc	9.58c	4.26cd	0.72c	3.23b
Poultry	57.70b	21.30ab	47.58	8.10a	45.50ab	5.78a	4.40ab	10.18ab	4.89ab	0.75b	3.35ab
F. test	**	**	*	*	*	*	*	*	**	**	**
						1998					
Control	48.85c	20.83c	43.83c	5.70e	40.23c	4.94d	4.25b	9.19d	4.19c	0.71b	2.85d
Rabbit	50.05bc	22.58b	45.63c	6.13d	48.03b	5.65bc	4.35ab	10.00b	4.83b	0.72b	3.24bc
Pigeon	61.58a	26.58a	56.35a	9.05a	52.30a	5.89a	4.51a	10.40a	5.22a	0.78a	3.39a
Cow	52.75bc	22.83bc	48.30	6.77c	49.03ab	5.18c	4.35ab	9.53c	4.60b	0.72b	3.17c
Poultry	58.20ab	24.63ab	50.28	7.55b	49.68ab	5.30c	4.39ab	9.69c	5.11a	0.76a	3.30ab
F. test	*	*	**	**	*	*	*	*	*	*	*

*** and ** indicate $P<0.05$ and $P<0.01$, respectively, according to F. test.**
Means followed by a letter in common are not significantly different at the 5% level according to Duncan's test.

Organic manure treatments improved tomato fruit yield and quality (Table 8). Use of Pigeon or poultry manure resulted in significantly higher fruit yield per plant and average fruit weight than using rabbit or cow manure. Also, applying pigeon and poultry manures led to significant increases in acidity, vitamin C and T.S.S contents.

Table (8): Effect of soil organic manures on plant fruit yield and quality, and nematode reproduction in castle rock tomato plants infested with *Meloidgyne incognita* in the 1997 and 1998 seasons.

Organic manure	Fruit yield/plant (g)	Average fruit weight (g)	Acidity (%)	Vitamin C (mg / 100 ml fruit juice)	Total soluble solids (%)	Final nematode population (P_f) J_2/ 250 cm^3 soil	Root gall index (0-5)	Reproduction factor (R_f) (P_f/P_i)	Nematode reduction (%)
	1997								
Control	240.50 d	42.20 c	0.55 e	18.33 d	4.99 c	285.25 a	3.0	0.057	-
Rabbit	269.50 bc	44.73 ab	0.61 c	21.05 b	5.29 ab	195.50 c	2.0	0.039	31.46
Pigeon	303.50 a	47.00 a	0.64 b	21.60 b	5.46 a	85.75 e	1.0	0.017	69.64
Cow	251.00 cd	43.38 bc	0.58 d	19.98 c	5.14 bc	236.75 b	2.0	0.047	17.01
Poultry	288.50 ab	45.53 ab	0.67 a	22.43 a	5.38 a	121.00 d	1.0	0.024	57.69
F. test	**	**	*	*	*	**			
	1998								
Control	278.25 d	43.83 d	0.56 c	17.48 d	4.83 c	300.75 a	4.0	0.060	-
Rabbit	292.75 cd	45.33 cd	0.57 bc	19.73bc	5.01 bc	215.25 b	3.0	0.043	28.43
Pigeon	349.25 a	48.53 a	0.61 b	20.53 b	5.43 a	94.75 e	2.0	0.018	68.50
Cow	302.00 c	46.13 bc	0.57 bc	19.20 c	5.14 b	180.75 c	3.0	0.036	39.91
Poultry	322.00 b	47.75 ab	0.66 a	21.70 a	5.35 a	147.50 d	2.0	0.029	50.95
F. test	*	*	*	*	*	**			

*** and ** indicate P<0.05 and P<0.01, respectively, according to F. test.**
Means followed by the same letter are not significantly different at the 5% level according to Duncan's test.
R_f = reproduction factor, P_f = final population; P_i = initial population.

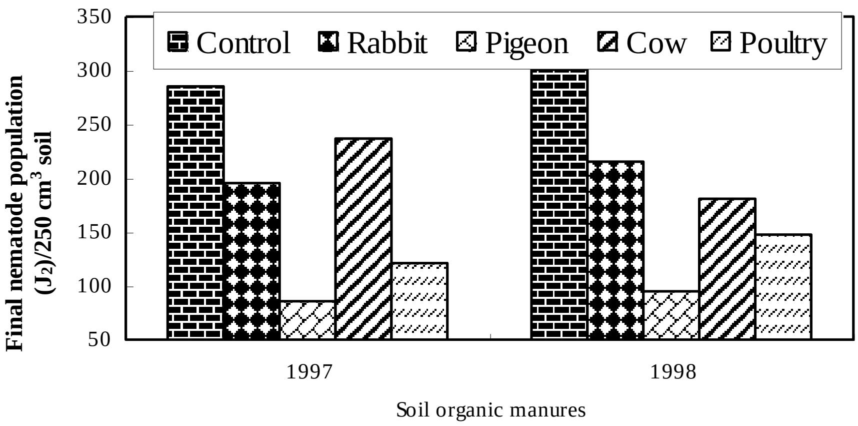

Fig. (1):Effect of soil organic manures on final population of *M. incognita* Infecting tomato plants (1997 & 1998).

Results in Table 8 and Figure 1 indicate that all soil organic manures greatly suppressed the final nematode population (P_f) and decreased root gall index. Reproduction factor (R_f) and galls index significantly decreased with applying pigeon or poultry manure, whereas rabbit and cow manures caused less suppression as compared with the unamended treatment in both seasons. Using pigeon or poultry manure led to pronounced reductions in percentage of nematode populations (69.64 &57.69 and 68.50 &50.45 for the two manures in the first and second seasons, respectively). However, less reduction was observed with rabbit and cow manures (31.46 &17.01 and 28.43 & 39.91).

DISCUSSION

Results obtained indicate that the susceptible tomato cv. Castlerock was greatly suppressed by *M. incognita* in most growth and yield parameters measured, whereas the resistant cv. Heinz 2710 was only slightly affected. Also, P_f, root gall index and (R_f) markedly increased in the case of susceptible cv. These results are in agreement with those of Anwar and Van Gundy (1993). They postulated that the high response of susceptible cvs. to nematode infection suggests a degree of aggressiveness of *M. incognita* which lead to growth retardation and death of plant more than in the resistant cvs. Also, our results support those of Taylor (1975) who reported that in susceptible cvs. all the infection sites were galled and contained giant cells and larvae in large numbers and that mature females were found within 30 days. It seems that mechanisms of resistance to root-knot nematodes are complex as reported by Khan and Khan (1991). In some incompatible reactions with plants *M. incognita* may fail to penetrate, penetrate only for a short period, penetrate in low numbers or penetrate in numbers equal to those in compatible plants but fail to develop. They added also that root exudates of susceptible cvs. may be different from those of resistant ones.

The present results indicate that the damage in all plant growth parameters was correlated with the increase in (P_i) level of *M. incognita.* This is in accordance with those of Sharma and Swarp (1968). They found in tomato seedlings infested with *M. incognita* and *M. javanica*, that the reduction in shoot growth was proportional to the reduction in root growth and both were highly correlated

Data show that the weight of roots proportionally increased with the increase in (P_i) level. This may be attributed to the higher numbers and weights of galls formed on infested roots.

Infestation of *M. incognita* significantly decreased chlorophyll content (a, b and a + b). These data confirm the finding of Ali *et al*. (1981) and Omar *et al*. (1985). Data also show that N, P, and K contents, in plant leaves, decreased as a result of nematode infection. These results are similar to those reported for nitrogen (Shaffiee and Jenkins, 1963), phosphorus (Dropkin and King, 1956) and; potassium (Oteifa, 1952; Ibrahim *et al*., 1982 and Fatemy and Evans, 1986) contents in nematode infected plants.

Fruit yield and average fruit weight decreased with the increase in (P_i) levels. The reduction in fruit yield could be ascribed to modification of plant physiological functions like photosynthesis, transpiration, mineral uptake and translocation following infection. A similar suggestion was reported by Chindo and Khan (1988).

Results indicate that there was a significant increase in (P_f) with each increase in (P_i). Root gall index ranged from 0.0 to 5.0 (with the different inoculum levels). R_f increased with the increase in (P_i) up to 10×10^3. These results agree with those reported by Abwai and Barker (1984) and Chindo and Khan (1988).

Soil organic manures significantly improved most vegetative growth parameters, chlorophyll and N, P and K contents in plant leaves and fruit yield and quality. Also, all soil organic manures suppressed the final nematode population (P_f), root gall index, reproduction factor (R_f) and increased nematode reduction %. These results are in agreement with those reported by Chindo and Khan (1986); Montasser (1991); Ismail and Yossif (1997) and Chavarria Carvajal and Rodriguez Kabana (1999). Such beneficial effects of organic manures may be partially due to their serving as soil amendments and partially due to their nematicidal activity.

The reduction in nematode population can be attributed to stimulation of soil microorganisms that are capable of parasitizing eggs or producing toxic substance which prevent egg hatching or destroy nematodes. Similar mechanisms were suggested by Heald and Burton (1968) and Muller *et al*., (1982).

Meanwhile, results of the present study indicate that organic manures with narrow C/N ratio (pigeon and poultry) were more effective against nematode than those with broad C/N ratio (cow and rabbit).These results are in agreement with those of Mian and Rodriguez Kabana (1982) who reported that the relative effectiveness of organic amendments depended on their nitrogen content and C/N ratio. Badra and Shafiee (1979), Rodriguez Kabana and King (1980) and Rodriguez Kabana *et al*. (1981) suggested that the action of organic amendments against phytonematodes may be due to the release of volatile organic acids and ammonical nitrogen during microbial decomposition of the organic materials in soil. As a result of microbial activity the pH value increases, stimulating processes of nitrification and production of nitrates, which can convert into ammonia and nitrates. Such compounds are toxic to nematodes, and also become toxic to plants at high levels of accumulation. They concluded also that the nematicidal action of ammonia may result from its capacity to generate higher osmotic pressures, which are lethal even in low concentration. Abdel-Rahman (1977) reported that the presence of certain amino acids such as alanine, argenine, aspartic, glutamic, glycine, histidine, isoleucine, leucine and phenylalanine in the decomposed manures is responsible for its toxic effect on nematode stages.

However, the involvement of other control mechanisms of organic manures against nematodes can not be excluded. Alam *et al*. (1980) suggested that the roots of plants grown in amended soil undergo physiological changes which make the roots unfavorable for nematode penetration and feeding; thus, inducing certain degrees of resistance against nematode attack.

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تـأثير نيمـاتودا تعقـد الجـذور (ميلويـدوجيني إنكوجنيتـا) علـى النمـو والمحصـول لأصنـاف الطمـاطم القابلـة للإصـابه والمقاومـة وتـأثير أنـواع مختلفـة مـن الأسـمدة العضوية على مكافحة النيماتودا

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أجريت تجربتى أصص- فى نفس الوقت- خلال الموسم الصيفى المبكر لعامى 1997، 1998.

فى التجربة الأولى – تمت دراسة تأثير أربعة مستويات من العدوى الأولية بنيماتودا تعقد الجذور ميلويـدوجيني إنكوجنيتـا (صـفر، 4×10^{3} ، 10×10^{3} و20×10^{3} بيضه/أصـيص) علـى النمـو والمحصول لصنفى الطماطم كاسل روك (القابل للإصابه) وهجين Heinz 2710 (المقاوم).

أوضحت النتائج أن النيماتودا قد تسببت فى أحداث تثبيط كبير فى معظم صفات النمو والمحصول للصنف القابل للإصابه مثل طول الساق، وعدد الأوراق، والوزن الطازج والجاف للأوراق، والوزن الطازج للجذور، ومحتوى الأوراق من الكلوروفيل والعناصر الأولية (النتروجين والفوسفور والبوتاسيوم)، والمحصول الثمرى لكل نبات، ومتوسط وزن الثمرة – هذا وقد كان التأثير بسيطاً للنيماتودا على الصنف المقاوم0 ومن ناحية أخرى فإن قيم الحموضه، وفيتامين ج، والمواد الصلبه الذائبه الكلية فى الثمار كانت أعلى فى الصنف القابل للإصابه0 وأظهرت النتائج أن كلاً من العدد النهائى للعشيرة النيماتودية، ودليل العقد الجذرية ومعامل التكاثر قد ازداد معنوياً فى الصنف القابل للإصابه بالمقارنة بالصنف المقاوم.

وتبين من النتائج وجود علاقه سالبه بين مستويات العدوى الأولية ومعظم صفات النمو الخضرى حيث لوحظت زيادة تدريجية فى كل منها بزيادة مستوى العدوى. ومن ناحية أخرى فقد لوحظ وجود علاقه موجبه بين كل من الوزن الطازج للجذور ومستوى العدوى. هذا وقد تناقص المحصول الثمرى لكل نبات مع زيادة مستوى العدوى. أما بالنسبة لمتوسط وزن الثمرة فقد تناقص معنوياً عند مستوى العدوى 20×10^{3} مقارنة بالكنترول. وقد انخفض محتوى الثمار من الحموضه وفيتامين ج عند معظم مستويات العدوى المستخدمه. وأوضحت النتائج أيضاً أن العدد النهائى للعشيرة النيماتودية قد ازداد بزيادة مستوى العدوى. وقد تراوحت قيمة دليل العقد الجذريه بين (صفر) فى حالة الكنترول الى (خمسة) فى باقى مستويات العدوى. وقد تزايد معامل التكاثر بزيادة مستوى العدوى حتى مستوى 10×10^{3}.

أظهرت النتائج وجود تأثير معنوى للتفاعل بين صنف الطماطم ومستوى العدوى الأولية على كل من الوزن الطازج للأوراق، ومحتوى الكلوروفيل فى الأوراق، والمحصول الثمرى لكل نبات حيث أعطى المستوى (صفر) مع الصنف المقاوم أعلى القيم ؛ ومن ناحية أخرى فقد أعطت نفس هذه المعاملة أقل وزن طازج للجذر. وقد تم الحصول على أقل عدد من العشيرة النيماتودية عند مستوى 4×10^{3} مع الصنف المقاوم. أما بالنسبة لدليل العقد الجذرية فقد تأثر بدرجة بسيطة بمستويات العدوى الأولية في الصنف المقاوم، وبدرجة كبيرة بهذه المستويات في الصنف القابل للإصابة. هذا وقد نتجت أقل قيمة لمعامل التكاثر عند مستوى العدوى 20×10^{3} مع الصنف المقاوم.

وفى التجربة الثانية تمت دراسة تأثير أربعة أنواع من الأسمدة العضوية (مخلفات الأرانب، والحمام، والأبقار، والدواجن) فى مكافحة نيماتودا تعقد الجذور ميلويدوجيني إنكوجنيتا التى تصيب نبات الطماطم. وقد أوضحت النتائج أن كل أنواع الأسمدة العضوية المستخدمة أحدثت تحسناً ملحوظاً فى معظم صفات النمو والمحصول للنباتات مثل طول الساق، وعدد الأوراق، والوزن الطازج والجاف للجذر، ومحتوى الأوراق من الكلوروفيل والعناصر الأولية (النيتروجين والفوسفور والبوتاسيوم)، والمحصول الثمرى لكل نبات، ومتوسط وزن الثمرة، والحموضه، وفيتامين ج، والمواد الصلبة الذائبه الكلية. هذا وقد أدى استخدام سمادى الحمام والدواجن الى زيادة قيم هذه الصفات المختلفة بدرجة أكبر منه عند استخدام سمادى الأرانب والأبقار.

وقد أحدثت كل الأسمدة العضوية المستخدمة نقصاً ملحوظاً فى كل من العدد النهائى للعشيرة النيماتودية, ودليل العقد الجذرية، ومعامل التكاثر. هذا وقد أحدث استخدام سمادى الحمام والدواجن خفضاً أكبر فى كل من دليل العقد الجذرية، ومعامل التكاثر، مع زيادة واضحة فى النسبة المئوية لتناقص أعداد النيماتودا، وذلك بالمقارنة بسمادى الأرانب والأبقار.